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TEST PLAN

FOR

PILOT TEST PROGRAM

FOR

REMOVAL OF EXCESS FLUORIDE

FROM

ACTIVATED CARBON EFFLUENT

FOR

THE DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL
(REF. CONTRACT #DAAA05-79-C-0006)

By

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IN ACCORDANCE WITH A DIRECTIVE FROM THE COLORADO DEPARTMENT OF HEALTH, THE REINJECTION WATER AT THE NORTH BOUNDARY OF RMA WILL BE SUBJECT TO DRINKING WATER STANDARDS ESTABLISHED BY EPA AND CDH. IN RESPONSE TO THIS DIRECTIVE, RUBEL AND HAGER ENGAGED TO PERFORM A FEASIBILITY STUDY DURING SEPTEMBER 1978. THE RESULTS DOCUMENTED THAT USING THE ACTIVATED ALUMINA TREATMENT METHOD, THE EXCESS FLUORIDE CAN BE REMOVED FROM THE CARBON TREATED WATER AT THE REINJECTION SITE. AT THE CONCLUSION OF THE FEASIBILITY STUDY, IT WAS DETERMINED THAT FURTHER PILOT TESTING WOULD BE NECESSARY TO OPTIMIZE THE CAUSTIC REGENERATION PROCEDURE FOR MAXIMUM LONG-TERM ECONOMY. THEREFORE, THIS PILOT TEST PROGRAM HAS BEEN ESTABLISHED. UNDER THIS PROGRAM THE FOLLOWING TASKS WILL BE: (1) TO DETERMINE WHETHER THERE ARE ANY INTERFERENCES PRESENT IN THE ACTIVATED CARBON EFFLUENT THAT MAY REDUCE THE EFFICIENCY OF THE PROCESS, (2) AN OPTIMUM ALUMINA REGENERATION PROCESS WILL BE DEVELOPED TO MINIMIZE OPERATING COSTS, (3) THE WORKING CAPACITY OF THE ACTIVATED ALUMINA ALONG WITH CHEMICAL CONSUMPTION UPON

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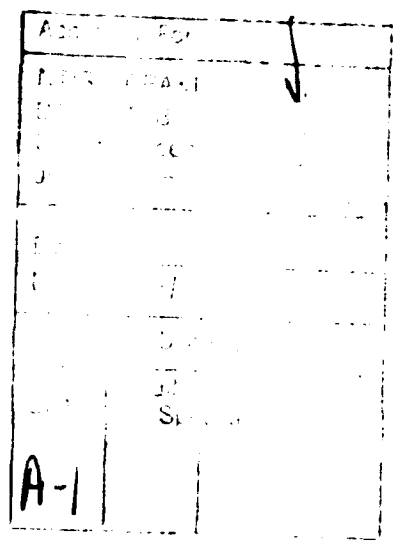

INTRODUCTION

In accordance with a directive from the Colorado Department of Health, the reinjection water at the north boundary of the Rocky Mountain Arsenal will be subject to drinking water standards established by the U.S. Environmental Protection Agency and the Colorado Department of Health. In addition to organic limitations for which purpose the granular activated carbon system was installed, there is also a specific limit of 2.4 mg/l of fluoride.

In response to this directive, this firm, Rubel and Hager, Inc., was engaged by the Rocky Mountain Arsenal to perform a feasibility study[1] during September 1978. The results of that study documented that using the activated alumina treatment method the excess fluoride can be removed from the carbon treated water at the reinjection site. That study, consisting of two complete treatment cycles including chemical regeneration, demonstrated the removal of fluoride from levels of 4-5 mg/l to an average of 1 mg/l. A capacity of more than 2,000 grains of fluoride per cubic foot of activated alumina was achieved in both cycles. That fluoride removal level is far below the maximum contaminant level requirement for fluoride of 2.4 mg/l established by the EPA and the Colorado Department of Health. At the conclusion of the feasibility study, it was determined that further pilot testing would be necessary to optimize the caustic regeneration procedure for maximum long term economy. Therefore, this pilot test program has been established.

This program will determine whether there are any interferences present in the activated carbon effluent that may reduce the efficiency of the process. An optimum alumina regeneration process will be developed to minimize operating costs. The working capacity of the activated alumina along with chemical consumption upon which a full-scale plant can be designed will be determined. And finally, as the pilot test program progresses, any other technical or economic facet requiring resolution which may be uncovered during the course of the test program can also be investigated. This program shall have the flexibility to incorporate any additional investigative features requested by Rocky Mountain Arsenal directive.

TEST APPARATUS

The test apparatus is a fully assembled skid-mounted treatment system (see Appendix for Schematic Flow Diagram). The system is designed to treat the activated carbon effluent at the rate of 5 gpm at 50 psig maximum working pressure. There are two treatment vessels (fourteen-inch diameter by eighty-four inches high) each contains 3.5 cubic feet of Alcoa (grade F-1, -28+48 mesh) activated alumina. This manually operated system is piped to permit one treatment unit to perform design flow treatment individually, or two units can be operated in either series or parallel. The system contains 1" PVC schedule 80 threaded pipe and fittings with manually operated full port ball valves. Accessories for each treatment unit include pH sensors with panel mounted indicators at inlet and outlet, sample points at inlet and outlet, a pressure gauge, an air vent, a flow totalizer, injection points for acid and caustic, and an in-line static chemical mixer.

The system also includes a feed water pump, a caustic feed system, an acid feed system, a zeolite softener, and sample points. The caustic feed system includes one twelve gallon solution tank and one metering pump for 50% sodium hydroxide. The caustic is employed during regeneration only; therefore, one pump serves both treatment units. The acid feed system includes one fifty gallon solution tank and two metering pumps for dilute sulfuric acid. One acid pump is required for pH adjustment for each treatment unit. The zeolite softener is an optional feature which can be used to pretreat raw water during caustic regeneration. There are also provisions for adding other pretreatment equipment, or additonal treatment units.

The entire treatment system is mounted on a steel skid (six feet wide by ten feet long) which is elevated approximately eighteen inches above the floor. The skid will be located adjacent to the activated carbon system in the north boundary treatment building. Raw water shall be piped (by others) from the carbon adsorbers to a 1-1/4" female threaded connection in the feed water pump suction line. The treated water shall be piped (by others) from a 1" female threaded connection to a designated discharge point. Regeneration wastewater shall be piped (by others) from a 1" female threaded connection to a designated contaminant vessel. An electrical service consisting of two--20 amp, 115v, 1 phase, 60 Hz circuits shall be provided (by others).

TEST PROGRAM

The scope of the test program for the 5 gpm pilot includes six complete treatment cycles. Each cycle consists of a treatment run through exhaustion of the treatment bed followed by a chemical regneration.

Treatment Unit No. 1 shall be designated as the primary treatment unit; Treatment Unit No. 2 shall be designated as the standby treatment unit. Initially all testing will take place in the primary unit. That will be a minimum of three treatment cycles. If initial test results indicate no loss of efficiency due to interference from competing ions in the raw water, then the remaining three treatment cycles will be employed to minimize cost of chemical regeneration. The standby treatment unit can then be operated in parallel with the primary treatment at a total flow rate of 10 gpm simulating the operation of a typical full-scale plant. If interference(s) exist which could degrade the treatment efficiency, it (they) will be identified during the initial testing phase. Method(s) for eliminating such interference(s) will be determined and implemented into the test program. Speculation as to what interference(s), if any, may exist in the raw water at this time is premature. However, provisions for future pretreatment for removal of interference(s) are incorporated in the system. In special cases where pretreatment is not available or impractical, a sacrificial treatment bed may be the best solution. In such a case, the primary treatment unit would be used as the sacrificial bed followed in series by the standby treatment unit. The primary (sacrificial) bed would then be employed to remove the interference; and the standby bed would be employed solely for

fluoride removal. The sacrificial bed might require periodic replacement. Determination of interference(s) will require decisions on the proper solution during the course of the test program.

Upon completion of the installation of the pilot plant test apparatus, initial start-up procedures can begin. This entails placing the treatment media in the vessels and properly back flushing. Concurrently all instruments will be calibrated and mechanical equipment checked out. The EPA Technical Report, "Removal of Excess Fluoride from Drinking Water" by Rubel and Woosley[2] elaborates upon start-up and operating procedures which apply to this type of treatment plant.

The primary treatment unit can then start the first (virgin) treatment run. During all treatment runs, Rocky Mountain Arsenal personnel shall perform all pilot plant surveillance and operating functions which includes (but not limited to) the following:

1. Monitor raw water flow rate, maintain at 5 gpm$\pm$1/4 gpm
2. Monitor raw water pH, maintain at 5.3-5.5 (unless directed otherwise by Rubel and Hager, Inc.)
3. Sample raw and treated water for analysis at four hour (or less) intervals. Record pH and fluoride levels at time of sampling. Collect thirty two-ounce samples for analysis by Rocky Mountain Arsenal laboratory.
4. Maintain record at pilot plant of flow rate, total flow, pH and fluoride levels. Note all events.
5. Maintain supply of dilute acid in solution tank. Record all concentrated acid additions.
6. Report status and activity to Rubel and Hager, Inc. on daily basis.

7. The Rocky Mountain Arsenal laboratory shall analyze all raw and treated water samples for all elements designated by Rubel and Hager, Inc. and approved by the Rocky Mountain Arsenal Contracting Officer's Representative.

Upon saturation of the treatment bed with fluoride which signifies completion of the first reatment run, a representative of Rubel and Hager, Inc. will meet with the Contracting Officer's Representative to review the pilot plant operating records and laboratory analyses. Decisions will be made at that time determining the regeneration procedure. Regeneration will be performed by Rubel and Hager, Inc. personnel. The initial plan is to backwash at 10 gpm for ten minutes. Then drain the bed, followed by an upflow regeneration with 75 gallons of 1% sodium hydroxide using softened raw water to dilute 50% sodium hydroxide at a flow rate of 2.5 gpm for thirty minutes. This is to be followed by an upflow soft water rinse of 5 gpm for thirty minutes followed by another draining of the liquid level down to the top of the bed. Finally, a downflow regeneration identical to the upflow described above shall be accomplished. This is to be followed by downflow neutralization using soft raw water adjusted to pH 2.5 for thirty minutes. At this point, it is planned to switch over to unsoftened raw water for the duration of the neutralization and treatment run. When the pH of the treated effluent drops to 7.5, the pH of the raw water will be adjusted to 3.5. When the pH of the treated effluent drops to 6.5, the pH of the raw water will be adjusted to 5.5.

Wastewater from the regeneration and neutralization (no backwash water) will be collected in a storage vessel (by others)

for study of ultimate disposal methods. The regeneration described above will be modified, as necessary, to adjust to the conditions that evolve during the test run. It is desirable to conduct the treatment run evaluation as soon as possible after the completion of the run. Thereby, treatment cycles can be continuous for all practical purposes. This will entail very rapid turn around time for analyses of water samples submitted to the Rocky Mountain Arsenal laboratory.

Subsequent treatment runs and regenerations will be conducted in the same manner. Of utmost importance is daily telephone communication between Rocky Mountain Arsenal surveillance personnel and Rubel and Hager, Inc.

It is estimated that a treatment cycle including regeneration can be completed within one week. Therefore, the six cycles should be accomplished within six weeks of start of pilot plant operation. Plans are to start pilot plant operation on or about May 15, 1979.

APPENDIX

FLUORIDE REMOVAL PILOT PLANT SCHEMATIC FLOW DIAGRAM, DRAWING NUMBER S-P-100

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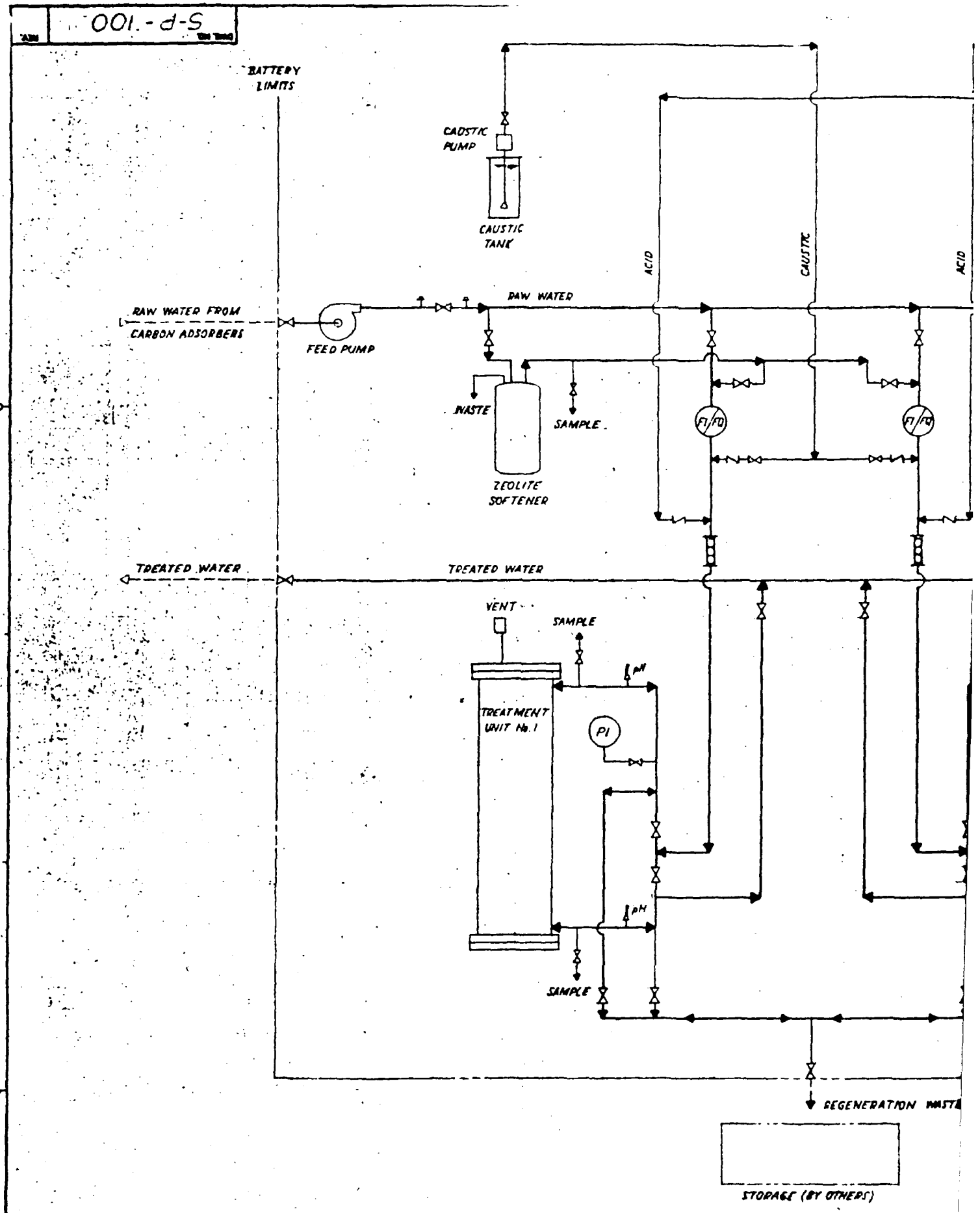
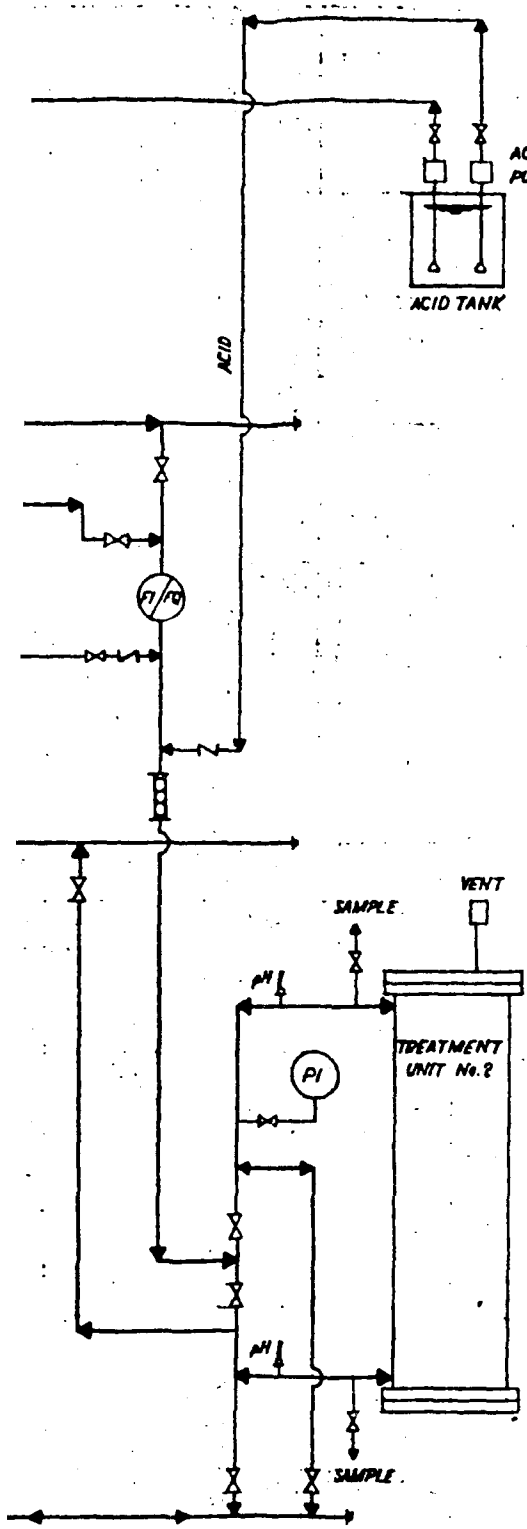

BATTERY LIMITS
CAUSTIC PUMP
CAUSTIC TANK
ACID
CAUSTIC
ACID
RAW WATER
RAW WATER FROM CARBON ADSORBERS
FEED PUMP
WASTE
SAMPLE
FI/FQ
FI/FQ
ZEOLITE SOFTENER
TREATED WATER
TREATED WATER
VENT
SAMPLE
pH
TREATMENT UNIT No. 1
PI
pH
SAMPLE
REGENERATION WASTE
STORAGE (BY OTHERS)



REGENERATION WASTE

(OTHERS)

LEGEND

- FEED PUMP
- IN LINE STATIC MIXER
- INJECTION BALL CHECK
- SHUT OFF VALVE
- PI – PRESSURE INDICATOR
- FI/FQ – FLOW INDICATOR/TOTALIZER

Rubel and Hage
CONSULTING ENGINEERS

PROJECT: ROCKY MOUNTAIN ARSENAL, CO

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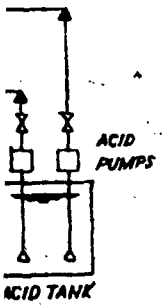

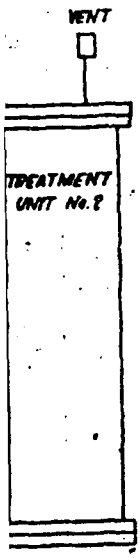

LEGEND

- FEED PUMP
- IN LINE STATIC MIXER
- INJECTION BALL CHECK
- SHUT OFF VALVE
- PI – PRESSURE INDICATOR
- FI/TO – FLOW INDICATOR/TOTALIZER

Rubel and Hager, Inc.
CONSULTING ENGINEERS ..... TUCSON, ARIZONA

PROJECT: ROCKY MOUNTAIN ARSENAL, COLORADO

DRN. DODD	FLUORIDE REMOVAL PILOT PLANT
CHK. FR	SCHEMATIC FLOW DIAGRAM
APPD. FR	
DATE 3-1-77	
SCALE NONE	DRAWING NUMBER S-P-100
	REV.

REFERENCES

1. Rubel and Hager, Inc., "Feasibility Study for the Removal of Excess Fluoride from Activated Carbon Effluent", The Department of the Army, Rocky Mountain Arsenal (Ref. #DAAA05-78-M-0914), ITARMS Project No. 1.05.15, September 30, 1978
2. Rubel, Jr., Frederick and Woosley, R. Dale, "Removal of Excess Fluoride from Drinking Water", Technical Report EPA 570/9-78-001, Jan. 1978